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TECHNICAL SERIES NO. 12, PART II.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

HABITS AND LIFE HISTORIES

OF SOME

FLIES OF THE FAMILY TABANIDÆ.

By JAMES S. HINE,
Of the Ohio State University, Columbus, Ohio.

ISSUED AUGUST 29, 1906.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 11, 1906.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled "Habits and Life Histories of some Flies of the Family Tabanidæ" (horseflies), prepared by Prof. James S. Hine, of the Ohio State University, Columbus, Ohio. As is well known, the insects of this family are injurious and annoying to human beings, and especially to horses and cattle, from their bites; but aside from this, and what is of much greater importance from an economic view-point, there is reason to believe that they sometimes act as agents in the transmission of infectious diseases. Every contribution to a knowledge of their habits and life histories is, therefore, of especial value. The present paper embodies the results of original investigations begun by Professor Hine during the summer of 1904 while a special field agent of this Bureau, and I recommend its publication as Part II of Technical Series bulletin No. 12.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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MISCELLANEOUS PAPERS.

HABITS AND LIFE HISTORIES OF SOME FLIES OF THE FAMILY TABANIDÆ.

By James S. Hine, *Columbus, Ohio.*

THE BLACK-STRIPED HORSEFLY.

(*Tabanus lasiophthalmus* Macquart.)

This species was reared from the egg to the adult. The fly is one of the earliest of its genus to appear in the spring, adults having been taken at Columbus, Ohio, as early as May 20, and it is common during the first half of June. The eggs are placed in masses on various plants that grow in low, wet ground, but I have not observed them over water. The masses are pure shining black when fully colored, rather small for members of the genus, only slightly convex, and accompanied with an unusual amount of cementing material, which nearly obscures the form and arrangement of the individual eggs. The mass in place suggests somewhat a drop of tar or other black substance fastened to the surface of a leaf of the common cattail reed (*Typha latifolia*), a sedge, or some other plant.

The eggs are usually deposited after the 10th of June, and the specimens from which larvæ for rearing hatched were taken in Medina County, Ohio, on a common sedge found growing near the outlet of a small spring. They were collected June 28 and hatched the next day and the day after. As I had not been successful up to this time in keeping very young larvæ for any length of time, it was decided to try different methods of treatment in order to find out, if possible, which is best suited to their requirements. Some were placed in a jar containing water only; others in a jar containing water with a couple of inches of sand in the bottom. A third jar in which larvæ were placed contained wet muck, while the fourth lot were placed in a jar containing moist sand to the depth of about 3 inches, covered over the top with a quantity of fine leaves of water plants. In all the breeding jars were placed plenty of small crustaceans and other minute invertebrates procured from water by means of a fine-meshed sieve.

It was soon observed that the larvæ in breeding jar No. 4 fed on the crustaceans and at the end of a few days showed a distinct increase in size. Those in the jars containing water soon died, and jar No. 3 did not appear to be a success, so all but No. 4 were abandoned. The larvæ in this last, however, were separated and placed in similar jars, one specimen in each, and reared to full size, the adult fly being procured the following spring.

Since, as stated, three of the four jars started with were soon abandoned, what is said hereafter regarding the method used in rearing pertains to the single one retained. A glass jar was selected so that the actions of the larvæ could be observed through it; a small jar seemed desirable because the larvæ are predaceous and eat their own kind as readily as anything else, for which reason it is necessary after a short time to place only a single specimen in a jar; also, even a small receptacle furnishes plenty of room, and the long series, which it is desirable to have, takes as much space in the insectary as one cares to give to a single species. Only the quantity of sand and other material necessary to success should be placed in the breeding jar, as it is desirable once in a while to look this material over carefully in order to locate the very small specimens and find out what they are doing.

All things considered, half-pint jelly glasses were found to be well suited for the purpose and easily obtainable. Covers proved to be desirable in order to prevent too rapid evaporation of moisture, but a small perforation or two in them was necessary to furnish ventilation. As the muck which was tested as soil for the jars grew much mold, clean lake sand was chosen as decidedly preferable for the purpose. The covering of plant material mentioned furnished a resting place for the small crustaceans offered for food, and the larvæ themselves seemed to choose to remain in it in preference to burrowing into the sand, although they were apt to be found in any part of the jar. Algæ made good material for covering, but only a small amount could be used, and too much water was detrimental, as either in excess tended to develop decay, and consequently a bad odor, which was observed to be unfavorable to the insects. The principal point in favor of the algæ, as compared with some other things, was that they contained no hollow stems or large pieces into which the larvæ could crawl, but still, because composed of small soft particles, furnished a mat in which they could hide. When it was desired to locate these larvæ it was easily done by picking the mass to pieces. As odors, which are often fatal to the larvæ, were likely to develop from the material put in for food and also from other sources, it was found necessary to watch the jars continually, giving them a thorough cleansing once in a while, and perhaps putting in fresh sand and plant material occasionally.

Larvæ when first hatched were about 2 mm. in length; they grew rather slowly, but in fifteen days after hatching had doubled their length. They fed readily on the small crustaceans which were given them. It was impossible to give these small crustaceans their proper surroundings, so many of them died, and it was observed that the young larvæ fed on these as well as on the specimens which they killed themselves. The larvæ could be seen crawling about in the jars; they appeared to remain very near the upper surface of the sand most of the time, and when food was scarce did much crawling, but when food was plentiful satisfied their appetites and hid among the plant material, where they remained quiet.

A difference in size in the various larvæ soon became apparent, and the older they became the greater this difference. On July 23, twenty-five days after hatching, some specimens measured as much as 7 mm., while others measured only 3 mm. At this date angleworms were given for food and were accepted readily, and appeared to be as satisfactory as the crustaceans, but it would seem that the latter are preferable for the stage just after hatching.

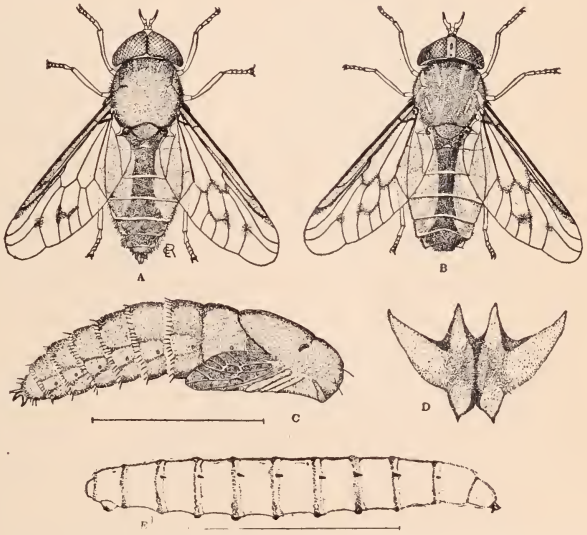

FIG. 1.—*Tabanus lasiophthalmus:* A, male; B, female; C, pupa; D, terminal abdominal teeth of pupa; E, undersized larva. All enlarged (original).

July 27 some of the larvæ were 10 mm. in length, and August 2 the same specimens measured 12 mm.; thus at this stage they grew more rapidly than when they were younger. They fed actively till about the middle of September, when they had become apparently full grown, or 25 mm. long. Length in the larvæ of tabanids is not a satisfactory means of indicating the size, for the segments telescope on one another in such a way that it is difficult to take two measurements exactly alike, but an endeavor was made in this case to make the different measurements similar, so I am satisfied that those given are sufficient to indicate the comparative sizes of the different ages. After the 15th of September the few specimens remaining alive buried themselves in the sand of the breeding jars and were quiet most of the time until the 10th of March, when one pupated, the adult emerging

on the 25th of the same month; the others died before the pupal stage was reached. I have noted that larvæ of various species of tabanids taken from their natural habitats during the winter did not produce adults in spring much before the same species appeared naturally, but in this case, where the specimen was kept under artificial conditions during its entire life, the adult appeared almost two months earlier than is normal in nature.

The mature larva (fig. 1, E) is not notably different from those of other species of Tabanus so far as form and appearance are concerned. The color is a dirty white with a pinkish shade over most of the body; the prolegs are not so prominent as in many species, and on this account specimens appear somewhat maggot-like. On either side of the body is a longitudinal row of very small black spots or specks, one to each segment and located just above the ventral prolegs; these spots are lacking on some of the anterior and some of the posterior segments; their presence appears to be characteristic of the species, at least so far as my acquaintance with different larvæ goes. Mature specimens are about 25 mm. in length.

I have not taken the larva of this species in its natural habitat, therefore can not say anything as to where it is to be found, but suspect it lives in débris, or in the ground around low places near where the eggs are laid.

The pupa (fig. 1, C) is somewhat dusky in coloration, the thorax being almost black. The terminal teeth of the abdomen (fig. 1, D) are quite different from those of any species studied so far, and these differences alone make its determination easy. The dorsal and lateral teeth are much larger than the ventral, the lateral being much larger than any of the others; the ventral teeth point almost directly backward, while the direction of the others is largely upward. The thoracic spiracle is rather small and nearly longitudinal, its rima is curved, but no distinct hook is formed at the posterior end. Length, 18 mm.

The adult (fig. 1, A, B) measures from 13 to 15 mm. Eyes pilose, ocelligerous tubercle present, wings hyaline, cross-veins and furcation of the third vein margined with brown, abdomen broadly red on the sides; female subcallus denuded and shining black, frontal callosity also shining black, as wide as the front and separated from a denuded spot above by a pollinose interval, front slightly widened above; male subcallus not denuded, eyes very plainly pilose, head about equal in size to that of the female.

THE AUTUMN HORSEFLY.

(*Tabanus sulcifrons* Macquart.)

This is one of the common species of its family over a wide range. It is not so generally distributed as some of the other species, but where it occurs is apt to be abundant and very injurious to all kinds of stock. I have studied the species in several localities, but most of my knowledge of its habits was gained in Summit and Medina counties, Ohio, where it is a pest of the first magnitude. This country, where the ground is highest, has an elevation of 1,000 to 1,200 feet, and is more or less broken by gullies crossing here and there, and through each flows a stream of clear water of larger or smaller

dimensions. These streams are fed by small springs and therefore contain water the year round, forming in their beds pools and riffles over which the sexes of *sulcifrons* may be seen flying much of the time.

I am not fully prepared to say why this particular species is so abundant in these counties and entirely absent in other counties of the same latitude in the western part of the same State; but it appears that there is present some condition which is necessary to its successful existence. The statement may be made in this connection that the autumn horsefly appears to prefer high ground, such as described,

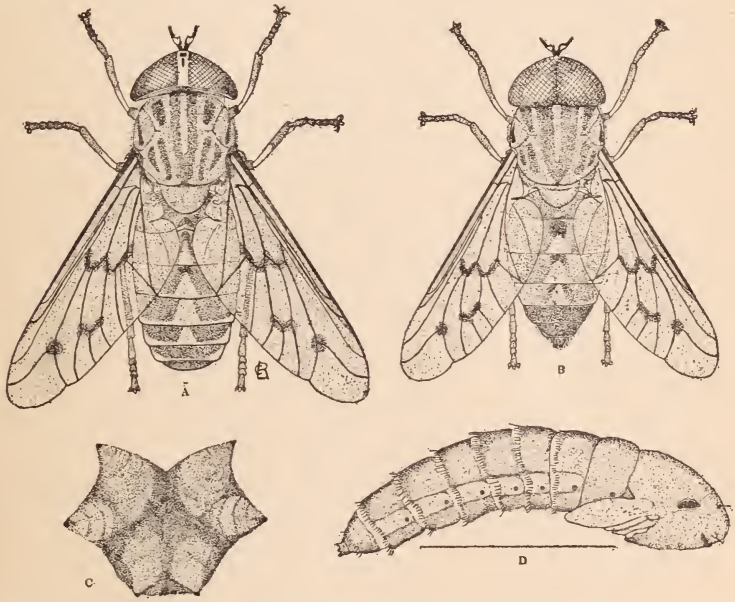

FIG. 2.—*Tabanus sulcifrons:* A, female; B, male; C, terminal abdominal teeth of pupa; D, pupa. All enlarged (original).

to low bottom land where many other horseflies find conditions exactly to their liking.

The adult (fig. 2, A, B) is a large brown fly 18 to 21 mm. in length. Palpi brownish, antennæ nearly black, with each third segment brownish at the base; legs dark, bases of the tibiæ lighter, the front pair black with the exception of the bases of the tibiæ and therefore much darker in general coloration than the others; wings with a distinct brownish tinge, cross-veins at the end of the discal cell, and the furcation of the third vein plainly margined with dark brown, first posterior cell open.

Female: Front of moderate width, sides parallel, frontal callosity shining brown, not quite as wide as the front, nearly square and with a linear prolongation above. Segments of the abdomen above with prominent, gray hind margins which expand into large gray triangles at the middle; usually a black marking on the anterior part of each of the second and third segments at the apex of the gray triangle.

Male: Division between the large and small facets of the eye prominent; head somewhat more convex than in the female, but of nearly the same size. Coloration in its entirety as in the other sex.

In Ohio the first specimens of the species usually appear about July 20 and specimens have been taken as late as the middle of September, but the period of greatest abundance is the first three weeks of August.

The adults are most in evidence when the sun is shining most brightly. As evening approaches they become less active and seek a resting place among foliage, on some tree trunk, on a fence or post, or in some similar place, where they remain quiet until the sun appears the following morning. These flies have a tendency to collect in certain favorable places in large numbers at evening, and if the collector or observer finds such a place, a visit to it by 7 o'clock in the morning will give an opportunity to procure plenty of specimens of both sexes, or abundance of notes on habits. When the sun has warmed the atmosphere somewhat, the flies begin to run over the objects on which they passed the night, or to fly from one perch to another. Both sexes are plentiful, the males often more plentiful than the females, and there is no difference in habits that makes it possible to readily distinguish the sexes. Specimens are easily taken, for by using care they may be picked up with the thumb and fingers, or if it is desired to use a net, it is not difficult to procure large numbers in a few minutes.

The only times I have observed copulation in the Tabanidæ were in places similar to the one just described and always about 8 o'clock in the morning. In a paper by the writer on the "Tabanidæ of Ohio"[a] it is recorded (p. 8) that on the 18th of August, between 8 o'clock and half past 8, several pairs of *T. sulcifrons* were observed in couple on the fence, and several pairs taken. The male in instances observed clung to the edge of a rail, and the female, with legs and wings motionless and touching nothing, hung suspended. My observations at this time led me to think that the opportunity for studying the mating habits of the species in question, and also of some others of its family, is confined to a particular time of day, and subsequent observations have not made it necessary to alter this opinion. On August 17 of the following year, about the same hour and near the place where the observations mentioned above were made, I captured nine pairs of the species, most of which were on the fence. At this time an effort was made to add to the data obtained before. It was then observed that when pairs were disturbed sufficiently to cause them to leave, the male did all the flying and proceeded only a short distance before alighting, either on the ground or on low-growing foliage, or it flew in a curve and soon returned to the fence. Coition in no case observed lasted over ten minutes, and all the pairs were taken within a quarter of an hour, after which time no more could be found.

As the hour became later fewer and fewer specimens were to be seen, and long before noon nearly all of the flies had left the places

[a] Ohio State Academy of Science, Special Papers, No. 5, May 1, 1903.

where they were so abundant earlier in the day. Either they had gone in search of food—the females to different animals for the purpose of sucking blood and the males to various places where they could find nectar and other liquid substances to their liking—or else they had gone to the water, over which could be seen both sexes flying in abundance, now and then striking the surface with their abdomens, but flying so rapidly that the observer had difficulty in determining the nature of their actions or what was accomplished by them. However, if the day was dark and cloudy there was not much activity among them, and on some of the cooler days or when it was raining they were hardly ever seen at all. An acquaintance with their habits at such times revealed the fact that they were passing the time among the foliage, usually on the underside of a leaf, where they remained quiet until pleasant weather appeared again.

The habits of the sexes while flying over water have been investigated a great deal, but after all there are some points not fully understood. There appears to be no choice as to the kind of water, for running brooks are chosen as well as stagnant ponds. At first there was some question in my mind as to whether both sexes have the habit of striking the surface in their gyrations over water, but observation soon proved that one sex as well as the other visits ponds and streams regularly, and so far as I could see there is no difference in their habits so far as the dipping is concerned, and specimens taken in the act bear out this statement. Over a small pond in which there was an abundance of aquatic vegetation in parts and open water in other parts, I observed many of the insects flying. Specimens, after flying about for a time, often came to rest on the foliage and sometimes on the surface of the open water. Under such circumstances the sex could be determined readily. Along swiftly flowing streams specimens found favorite resting places on the stones that protruded above the water, or else on the bank near the water's edge.

The food habits of the adults are of especial interest, and every opportunity for studying these was utilized. I am thoroughly convinced that the females take much other food than blood and do not believe it would be overstating the facts to say that specimens of this sex may pass the period of adult life without taking blood at all. Both sexes of *sulcifrons* run over foliage a great deal and often have been observed sipping up water that forms on the leaves as dew. This dew in many cases carries nourishment in solution, and on trees infested by aphides, scale insects, and various other species, especially of the order Hemiptera, much food material is included. Many leaves become coated with honeydew dried to a semisolid state. The water that collects on these leaves during clear nights dissolves some of this material and makes it available as food for horseflies. I have watched many specimens on wet stones and damp sand along brooks.

They move from one place to another, stopping now and then to sip up any small amount of liquid that they find, and if one watches closely he may see this liquid disappear from small depressions where they have introduced their sucking mouth parts. I have examined many specimens of both males and females and found their alimentary tracts filled with a liquid slightly yellowish in coloration, indicating that it contained something besides clear water. In Summit County, Ohio, some cucumber trees (*Magnolia acuminata*) were found to be thoroughly infested with a species of scale of the genus Eulecanium. Male and female flies visited these trees in numbers and fed on the honeydew excreted by the scale insects.

A number of species of the family Tabanidæ, aside from the one under consideration, have been observed feeding on the excretions of insects. At Sandusky, Ohio, within a few minutes I took the sexes of no less than six species of the genera Chrysops and Tabanus feeding on honeydew from an aphis, which was abundant on Phragmites, a large species of aquatic grass.

FIG. 3.—*Vespa maculata*, enlarged (original).

The various species of Tabanidæ have a great many natural enemies and *sulcifrons* is no exception in this regard. Aside from certain species of birds which are known to devour the flies occasionally, I have observed that the common bald-faced hornet (*Vespa maculata* L., fig. 3) is very active in capturing both sexes, either for food for itself or for its young. Around the cucumber trees mentioned above the flies were abundant, and while located under one of these one afternoon I saw something come tumbling down through the branches to the ground. When in position to see what it was, I found it to be a horsefly which was being held by a hornet. The matter was interesting, and I watched to see what transpired. The fly was too heavy for the hornet to carry, but the latter, equal to the occasion, immediately began to dismember the former, cutting off such parts as were not wanted. With its scissor-like mandibles, and otherwise well prepared for what was to follow, the hornet soon got into position and first clipped the slender neck of its victim, thus separating the head from the rest of the body. Legs and wings came next in order, and finally the abdomen; so that nothing was retained but the thorax. After lacerating this somewhat and disposing of some of the outer chitinous covering, it rolled the remainder into a sort of a ball and flew away with it—I suppose to its nest.

After one example of this kind had been observed, watch was made for others, and it was found that the occurrence was common. The hornets could be heard buzzing in all parts of the tree, and when one had the opportunity it pounced upon a fly and, holding on with its feet, came down with its prey to the ground, both insects making an abundance of noise with their wings.

August 6 under a single tree I saw the hornets kill three males and a female of the tabanid within the space of half an hour. At other times during succeeding days the occurrence was watched until it was proven that the habit is a natural one for this particular species of hornet.

Some variations in the actions of the hymenopteron were noted. In some cases, after cutting off the head and some of the appendages of the fly, it flew to one of the lower branches of the tree with the remains and finished the trimming while clinging to a twig by one hind leg and using the other legs to hold and manipulate its victim.

The possibility that the hornet stung its prey, when it first pounced upon it, was considered, and although there was no definite way of proving that such is not the fact, results of observation do not seem to indicate such a procedure. In one or two instances observed the pair came down into the water of a brook that flowed beneath the tree. Under these conditions the hornet became confused and released its hold on the fly, the latter flying away apparently unharmed.

Various species of spiders occasionally catch flies of this species, either by netting them in their webs or by jumping upon them from concealment.

The use of insecticides against adult horseflies has been more or less unsatisfactory, and whatever good has been accomplished has come almost entirely as a result of using some substance that acted as a repellent to the flies; for they are so retiring in their habits that as soon as anyone approaches with a sprayer an animal they are troubling, they are apt to leave and consequently do not usually receive a direct application. Effort on the part of different investigators to bring out an effective repellent has resulted in the testing of many substances which have penetrating odors. I have used a mixture prepared in the proportion of 1 pint of carbolic acid and 1 quart of pine tar to 3 gallons of kerosene. Application was made with a hand sprayer or atomizer, with the view of testing its effects on the adults of *Tabanus sulcifrons*. It was satisfactorily demonstrated that the mixture has properties as a repellent, but of such short duration that it could hardly receive practical consideration. When specimens were given a direct application they were readily affected and as a first result flew away a short distance and then dropped to the ground.

I have spent much time in an endeavor to work out the life history of this species, but my efforts have not been fully rewarded.

Although the eggs have been procured in many stages of development by dissecting the females, the habits of oviposition have not been observed. The form of the eggs and the number produced by a single female are as in other species of its size. Specimens containing eggs almost fully developed were taken in various places, but I could not get any clue as to where oviposition occurred by dissecting the females where they were collected, as I had hoped to do; therefore all that can be said at this time is, we hope to be able to obtain full information on the life history of the autumn horsefly in the future.

The pupa case (fig. 2, D) of the species was procured by locating a female which had just emerged. The place where this pupa case was taken is on a side hill, about 75 feet above the bed of a small stream. The description follows:

Length 26 mm., diameter 6 mm. Color yellowish brown, the thorax being nearly the same color as the abdomen. Tubercles of the head region well marked and distinctly darker than the surrounding parts. Prothoracic spiracular tubercle brown in color, elevated, narrow, ventral half oblique, dorsal half turned directly forward, thus forming a distinct bend near the middle of the length; rima nearly straight from outer end to the middle and evenly curved for the remainder of its length, inner tip curved backward, thus forming a well-defined hook. First abdominal spiracle nearly round; its rima following the posterior curvature, very narrow, but a little widened above; remaining abdominal spiracles a little smaller than the first one, each with a short, slightly curved or straight rima. Terminal abdominal segment with several small spines near the middle of its length and six larger spines at its apex (fig. 2, C). These spines are all brown in color, with the apex of each approaching black. Six apical spines of nearly the same size; the dorsal pair point upward, outward, and slightly backward, the lateral one on each side outward and backward, while the ventral pair extend almost directly backward. These six spines mark the corners of a hexagon with nearly equal sides, but the ventral pair are a little nearer together than the dorsal pair.

THE BLACK AND WHITE HORSEFLY.

(*Tabanus stygius* Say.)

This horsefly is very common in the vicinity of the Lake Laboratory, at Sandusky, Ohio, where most of my observations on the species were made. The adults appear about the 1st of July each season, and are on the wing for several weeks thereafter. The females were often observed biting cattle and horses, and are known to be important stock pests. The males were often seen in the marshes, on grasses infested by aphides, and it is known that this sex, and occasionally the females also, feed on honeydew which these insects excrete. The species oviposits principally on the leaves of Sagittaria standing in shallow water, habitually placing the eggs just above the point where the petiole meets the expanded part of the leaf (fig. 4). The precision with which this habit is followed becomes a matter of much interest. Out of hundreds of masses of eggs

observed, only a very few were placed on other species of plants or in a different position on the leaf (fig. 5). The female (fig. 6) is occupied for a half hour or more in placing the several hundred eggs composing a single mass, and during this time the observer can take a position close by and watch the proceedings without frightening her away, but species of Tabanus are more particular about the approach of intruders than are various Chrysops.

The egg mass (figs. 4, 5) is white when first placed but turns brown shortly; it is very convex, and is composed of about five layers, one above the other. Individual eggs are of nearly the same size as those

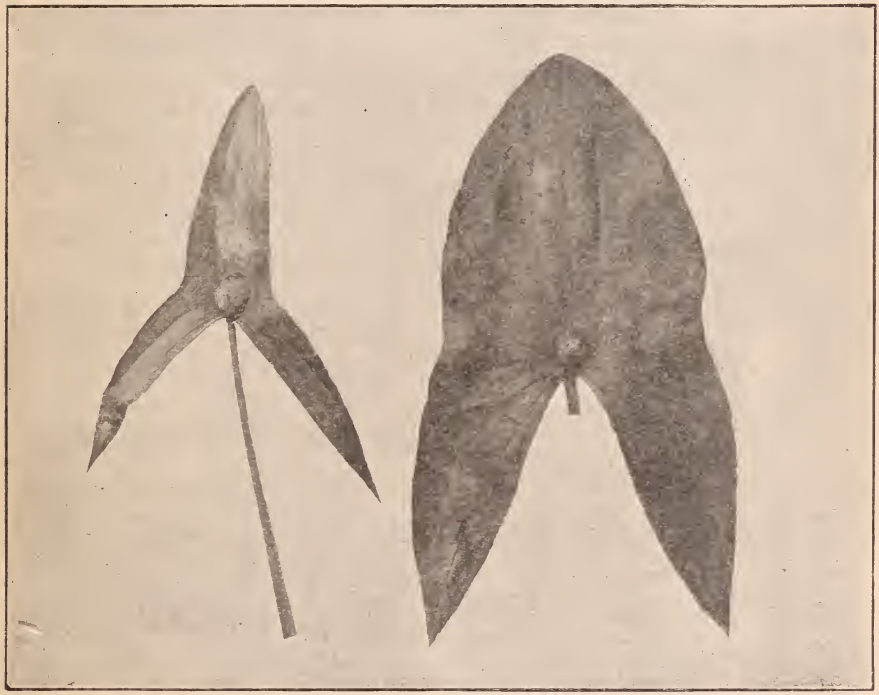

FIG. 4.—Eggs of *Tabanus stygius*, showing the location, with reference to the leaf, in which they are usually found. From a photograph; reduced (original).

of the black horsefly (*Tabanus atratus* Fab.), and are similar to them in form. Hatching, as observed, occurred in seven days after oviposition. From a careful study of microscopic sections of eggs killed as soon as laid it was concluded that development does not begin until after oviposition, consequently the time given is the entire incubation period.

When first hatched the larvæ contain a considerable amount of unused yolk, which furnishes them food for a time; it is therefore unnecessary for them to eat anything for a few days. This is advantageous no doubt, for food is not always just at hand, and in case it is

not, the fact that nourishment is furnished naturally gives them an opportunity to investigate their surroundings.

At hatching time nearly all the larvæ that come from a single mass of eggs appear at the same time and when they have freed themselves from the shells go tumbling down into the water, scattering more or less and sinking to the bottom, where it is difficult to observe their further actions.

FIG. 5.—Eggs of *Tabanus stygius*, showing a position in which they are not often found. From a photograph (original).

I proved to my satisfaction that horsefly larvæ are palatable to the small catfish (*Amiurus melas*), although I am not fully informed of how much value the fish is in destroying them under natural conditions. From a large number of these larvæ, hatched July 21, 200 were counted out on the morning of the 23d, and placed in a quart jar of water containing two young fishes slightly more than an inch in length. Before noon of the same day all the larvæ had been devoured. At another time 300 larvæ were put into an aquarium with 12 of the catfish, with the result that the former disappeared within the space of an hour or two.

July 21 a number of larvæ just hatched were placed in a breeding jar containing damp sand covered over the top with fine plant material, and small crustaceans were put in for food. The larvæ took kindly to the surroundings, accepted the food offered, and began to grow from the start. After a couple of weeks, as angleworms were much easier to obtain, these were substituted for the crustaceans, with no bad effects on the larvæ, which continued to grow, though rather slowly. The largest attained a length of about 10 mm. by the beginning of winter, when they ceased eating. They appeared to be in good condition in the spring, but for some reason died without further increase in size.

August 2, of the same year, I took a large larva of this species in Summit County, Ohio, from under a flat stone along a brook that ran from a spring. When taken this specimen measured over 40 mm. in length and had every appearance of being mature, but it continued to eat the angleworms given it until late in the fall. It then ceased feeding until the following spring, when it took a small amount of food and entered the pupal stage about the middle of May, the adult, a male, issuing June 14.

From what I have learned of the life cycle of the species it seems hardly possible that it passes all its transformations in a single year, for the larvæ reared from eggs were not over 8 mm. long when the specimen over 40 mm. long was collected; and as the latter did not produce the adult until about the normal time for adults to appear under natural conditions, it does not seem possible that the first-mentioned larvæ could have reached maturity and produced adults before the second year.

FIG. 6.—Adult female of *Tabanus stygius*. From a photograph; enlarged (original).

Larva, when first hatched, 4 mm. long; entirely light colored; form as in older specimens. As growth continues size is the only noticeable change.

The mature larva has been figured and described in detail by Hart in his paper, "On The Entomology of the Illinois River and Adjacent Waters."[a]

Pupa (fig. 7, A) 29 mm. long; color dark, approaching fuscous; prothoracic spiracle strongly bent at the middle; rima oblique and straight for the outer half of its length, remainder gradually curved, with a broad hook at the inner end. Teeth at the end of the abdomen (fig. 7, B) six in number, nearly equidistant from one another, of nearly the same size, with the extreme tips slightly turned inward.

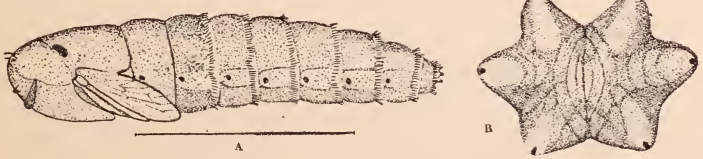

FIG. 7.—*Tabanus stygius:* A, pupa; B, terminal abdominal teeth of same. Enlarged (original).

The pupa of *stygius* is much like that of *sulcifrons*, but there is some difference in the prothoracic spiracles and in the abdominal teeth.

[a] Bul. Ill. State Lab. Nat. Hist., Vol. IV, Art. VI, pp. 239–240, Pl. XI, figs. 47, 48, 1895.

Adult 20 to 22 mm. in length. Third segment of the antenna reddish at the base, blackish at the apex; legs black, the front tibiæ reddish at base; wings yellowish brown, cross veins and furcation of the third vein margined with darker; abdomen uniformly black. Female, thorax plainly white pollinose; male, thorax uniformly grayish brown.

The species is nearly related to *T. nigrescens*, which has the thorax of the female almost uniformly black.

THE RIVER HORSEFLY.

(*Tabanus rivax* Osten Sacken.)

I have never observed this species to be especially common, but it is widely distributed, having been taken in a number of the Eastern

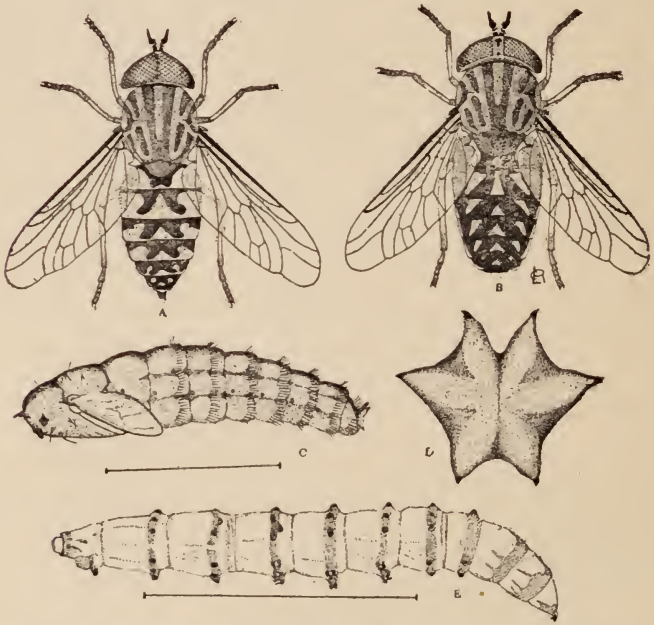

FIG. 8.—*Tabanus rivax:* A, male; B, female; C, pupa; D, terminal abdominal teeth of pupa; E, larva. All enlarged (original).

States. Since specimens are not plentiful they are not often observed around stock, but it is known that they have the same habits in this regard as the other members of the family. The male has been taken fully as often as the female, on protruding stones in swift-flowing streams, and in sunny spots in woods near such streams. The species is on the wing during the last half of June.

Adult (fig. 8, A, B) from 14 to 16 mm. in length, slightly elongate; antennæ black, first segment partially reddish in the female; thorax with five gray stripes separated by black; wings hyaline; legs black in general color, with the basal part of each tibia yellowish; abdomen with a prominent middorsal row of gray triangles and gray spots on each side.

Female: Palpi light yellow; front wider above than below, frontal callosity shining black, almost as wide as the front and with a narrow extension above. Abdomen with three rows of gray spots extending for its whole length; in this sex the gray spots are small but well defined.

Male: Palpi nearly black, much darker than in the female. The general arrangement of colors on the abdomen is the same as in the other sex, but the lateral gray spots are larger.

Eggs are placed on stones that project above the water in riffles of streams. They do not differ in particular from the eggs of other species of the genus, but the masses observed were not so convex as those of the black horsefly, and being placed on stones of a color similar to themselves are rather difficult to see. Females have been observed ovipositing as early as June 8, but most often eggs are deposited after this date.

Larvæ occur in the streams in the fall. In September and October each year we collect the larvæ of the dobson fly (*Corydalis cornuta* L.) for study in the laboratory. Whether we obtain these larvæ by turning stones at the edge of swift riffles, or by means of a net stretched across the riffles to catch such specimens as are dislodged by turning stones behind the net in the stream, we find plenty of the larvæ of this horsefly. I have collected much in streams, but the larva of the river horsefly is the only tabanid larva taken in riffles so far. I have not found it difficult to rear these larvæ, when taken at the season mentioned, by placing them in damp sand and feeding them on angleworms. As winter approaches they refuse to eat and take up a position in the sand and remain quiet until the following spring; then they feed actively for a few days and change to the pupa. Like other tabanid larvæ they are not particular as to their food; all that appears to be necessary is that they obtain small, soft-bodied animals. Crustaceans serve them as well as insects and their own species as well as some other species—whatever, in fact, is in the sand of the breeding cage.

Larva (fig. 8, E), when full grown, about 25 mm. long. General color yellowish white, anterior margin of each thoracic segment and a narrow band, including the prolegs, on the anterior half of the first seven abdominal segments opaque, and appearing darker than the other parts, which are more or less shining and usually finely striate longitudinally. Prothoracic segment divided by longitudinal grooves into four nearly equal parts, which may be called the dorsal, ventral, and lateral areas. The lateral areas are shining and finely striated on the posterior third and opaque on the anterior two-thirds; the dorsal and ventral areas are opaque on about the anterior fourth and distinctly shining on the remaining parts. The ventral space is plainly divided into two equal parts by a longitudinal groove. In order to see the character of this segment, it must be fully extended. The mesothoracic and metathoracic segments have a number of longitudinal grooves, some of which are very narrowly bordered by opaque darker coloring, which proceeds backward from the narrow anterior border of these segments. Each of the first seven abdominal segments has on its anterior part a transverse row of eight tubercles which encircle the segment. These all bear short spines or claws at the apex, excepting a dorsal pair on each of

the first three or four segments. They may be called prolegs, since they have the parts necessary to such organs and, what is more, are used as prolegs. On the posterior dorsal border of most of the abdominal segments there may be a narrow, irregular, opaque marking of the same color of the narrow band in the region of the prolegs; eighth segment on each side with two narrow, curved markings which have the appearance of being composed of contiguous punctures. These markings are of the same shade of color as the other darker areas, and the lower one is more than twice as long as the upper.

Pupa (fig. 8, c) 18 mm. long and 4 mm. in diameter. Light brown in color, thorax somewhat paler than the abdomen. Antennal and other tubercles of the head and thorax prominent and darker than the surrounding parts. Prothoracic spiracular tubercle slightly elevated, reniform, oblique; rima uniformly curved for nearly its whole length; but just before the anterior end the curvature is stronger, although no hook is formed. First abdominal spiracle nearly round; rima almost uniformly curved, posteriorly very slightly widened just at the end, anteriorly slightly narrowed and curved so as to form a short hook. The other abdominal spiracles agree with the first one in general, but there is slight variation in the enlargement and curvature of the extreme ends. Terminal teeth (fig. 8, d) prominent, shining brown in color, darkest at the extreme tips. Dorsal pair of teeth smallest and closer together than the ventral, lateral teeth longer and larger than the ventral and located much beneath the dorsal, in fact they are nearly midway between the dorsal and ventral.

THE BLACK HORSEFLY.

(*Tabanus atratus* Fabricius.)

The eggs of this horsefly—male and female adults of which are shown in figure 9—are placed in masses of various sizes on the leaves and stems of grasses and sedges and other plants growing in marshy or wet ground, but not necessarily in the water. A single mass may contain as many as 500 eggs, but often they are smaller and they may be larger; they are white when first placed, but soon turn brownish. The mass is very convex and composed of several layers, one above the other, the bottom layer being attached to the surface of the leaf or stem and the other layers each to the one that was placed before it. Each egg is elongate spindle shaped, between 2 and 3 mm. in length and narrowed at each end. A female was observed ovipositing June 23 at 11 o'clock. The eggs were taken and kept in a room out of the sun, where they hatched on the morning of July 2 before 6 o'clock, thus requiring an incubation period of nearly nine full days. It has been proven that the eggs of tabanids hatch more quickly when exposed to the sun during the day, as where they are usually deposited; therefore, the time given is probably too long for eggs under natural conditions.

There is no definite way, so far as observed, of telling the eggs of the black horsefly from those of other species of its genus, but being a large species the masses are much larger than in some others, and are more convex than usual. The particular place of oviposition is in a measure characteristic.

Larvæ, when first hatched, are about 3 mm. in length, white, and with a narrow darker shade at the union of each two segments. As soon as they drop to the ground they begin to burrow and are soon beneath

the surface, where they can not be seen. At first these larvæ are very hard to see on account of their small size; consequently not much has been learned of their habits under natural conditions; but when nearly grown they are to be found in a variety of places. Walsh was the first to make reference in writing to this species in the larval stage. He found specimens in floating débris and rotten logs and on one occasion under a log on dry land. I have taken them while digging in the ground in the vicinity of ponds, from under stones on ditch banks, from the water with dip nets, and occasionally in most unexpected places. However, if one is looking for them he is likely to meet with more or less disappointment, as the finding of one specimen does not indicate necessarily that others may be taken under the same conditions.

FIG. 9.—*Tabanus atratus:* Adult male at left, female at right. From a photograph; enlarged (original).

The fact that specimens have been taken from floating logs and débris suggests that they may be transported for longer or shorter distances in this way, and during high water stranded upon ground which, when the flood subsides, is high and dry and far removed from the bed of the stream. Since the species in all its habits is closely associated with water and wet ground, this seems to be the only way of explaining the appearance of larvæ in dry soil and in places remote from where the eggs are laid.

Full-grown larva nearly 2 inches in length. General color yellowish white, with wide dark brown bands at the union of each two segments. Prothoracic segment on each side with two lateral grooves, which do not quite reach the posterior border of the segment, and a dorsal groove continued for the entire length. These grooves and a number of irregular dots on the posterior part are dark colored, while the remainder of the segment is light. Mesothoracic segment, on each side, with four longitudinal grooves, which reach nearly the entire length. The dark markings on this segment include a narrow anterior border, the lateral grooves, and a number of

irregular dots near the posterior margin. The metathoracic segment is like the last, except that the dark color on the anterior margin is wider and the posterior, instead of being dotted, is uniformly brown. The abdominal segments are each similar to the metathoracic, but the dark markings in the region of the lateral grooves are more or less abbreviated. Last abdominal segment with two pairs of dark markings; the ventral pair extend the whole length of the segment and are connected just behind the anal prominence by a cross-band; the dorsal pair are oblong, somewhat irregular in outline, and extend from the anterior margin to beyond the middle of the length. At the anterior ventral border of each of the first seven abdominal segments is a transverse series of prolegs, three on either side of the midventral line. These prolegs are located within the dark transverse bands, but are lighter in color than these and prominent enough to be seen easily. Above the prolegs on either side of the middorsal line is a small swelling which appears as a rudimentary proleg; before the two is a distinct transverse light spot still within the dark area.

The head of the larva is very small for so large an insect and the mouth parts are minute. The mandibles consist of two strongly chitinized pieces, and work by being pushed endwise backward and forward. When drawn in, the anterior ends point directly forward, but when protruded, these same ends point downward and backward, thus forming a pair of hooks by means of which the prey is held. The larva is able to protrude its mandibles very quickly and to use them very effectively on soft-bodied invertebrates on which it is known to feed.

Pupa (fig. 10, B) about 1¼ inches in length. Color brownish yellow. Antennal and other tubercles of the head darker than the surrounding parts. Prothoracic spiracle

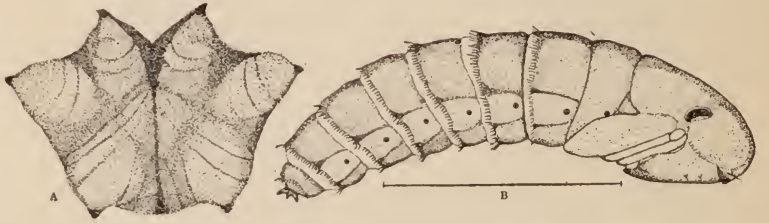

FIG. 10.—*Tabanus atratus:* B, pupa; A, terminal abdominal teeth of same. Enlarged (original).

slightly elevated, clear brown in color, reniform and oblique, rima gradually curved to near the dorsal end, where a distinct hook is formed by a sharp bend. Abdominal spiracles nearly round; rima of the first short and gradually curved and with a slight hook at the dorsal end. Terminal teeth (fig. 10, A) arranged in pairs, a ventral pair and a pair on each side formed by a dorsal and a lateral tooth. The distances between these teeth is variable; the two dorsal are nearest together, then follows the distance between a dorsal and a lateral, the distance between the two ventral, while the distance between a ventral and a lateral on each side is greatest of any.

THE MARSH EARFLY.

(*Chrysops mœrens* Walker.)

The marsh earfly is a common species in the marshes near the Lake Laboratory, at Sandusky, Ohio. The adults appear each year during the latter part of June and are abundant by the 10th of July. They continue to be common all through the latter month and August, and a few are to be found in September. Eggs were first observed during the first days of July and were present in varying numbers during the following two months.

During the time the female is ovipositing she is not easily disturbed;

consequently one has an excellent opportunity to watch the procedure. The accompanying illustration (fig. 11) was made from a photograph of a living specimen which was found in the act of egg-laying and carried, with the leaf, to the laboratory where the picture was taken. During the whole time she continued ovipositing without showing any signs that she was aware of what was going on or that she had any concern for the welfare of her eggs.

The method of placing the eggs is similar to that recorded for *C. callidus* in my paper on "The Tabanidæ of Ohio."[a] pages 4 and 5. The female alights on the leaf with her head downward and begins the process by pushing the tip of her abdomen forward toward the under part of the thorax and placing the protruding end of an egg against the leaf. The end sticks fast in consequence of the glue-like substance which accompanies it, and she then moves the tip of her abdomen back to its normal position, thus freeing the egg. By similar movements one or two eggs are placed to one side of the first, and two or three to the other side of it. The unfinished end soon becomes V-shaped; she moves slowly forward and lifts the tip of her abdomen to one arm of the V and places eggs along down until the apex is reached; then changes to the other arm of the V and places eggs along down to the apex on this side. It was noted in specimens of this species observed that sometimes a female would place as many as three rows of eggs on one side, one after the other. before changing to the opposite side. It is only necessary to study a mass of these eggs in order to see the precision, in reference to one another, with which the different specimens are arranged.

FIG. 11.—*Chrysops mœrens* ovipositing. From a living specimen (original).

The eggs (fig. 12) are placed on various aquatic plants, oftentimes standing in rather deep water and at times as much as 20 rods from shore. I have always found them on scattering plants around the edges of grassy areas and not back among the dense growth; consequently they are easily seen, not only on account of conspicuous location, but also because of their shining black color, which contrasts strongly with the green leaves to which they are attached.

It has occurred to me that, on account of the uniform methods of placing the eggs followed by various species and the strong contrast of these eggs with their surroundings, there are times when hand

[a] Ohio State Academy of Science, Special Papers, No. 5, May 1, 1903.

picking might be of consequence, although I realize that in most cases such procedure would not be practicable. In order to demonstrate what could be done in the way of gathering eggs of this species, on the morning of July 17 I went out in a small rowboat and collected for an hour. At the end of this time a count showed 433 masses, and an average of 250 specimens to each mass—a result obtained by counting several and striking the average—gives a total of 108,250 single eggs taken as a result of the hour's work.

FIG. 12.—Eggs of *Chrysops mœrens:* Four masses on short section of leaf of Spharganium. From a photograph (original).

Eggs laid from 8.45 to 9.30 o'clock on the morning of July 13 hatched before noon of July 19, thus making the incubation period six days in length. This is the shortest incubation period I have observed for any of the species of the family.

In a previous paper I suggested that kerosene might be of consequence if used on the surface of stagnant water over which eggs are in place, in order that the larvæ when they hatch and drop to the water must pass through a film of the oil. Data on this point are very difficult to obtain in the natural breeding grounds of the flies, for it is almost impossible to find the very small larvæ after they have dropped from the eggs and have become more or less scattered among the débris which is usually plentiful in these places. I undertook to test the matter by the use of a tank of water on the surface of which kerosene was placed at the rate of half a pint to each square yard of surface. Spharganium leaves to which eggs were attached were brought in from the marsh and put into a bottle, as one would arrange a bouquet, and this placed on the bottom of the tank so that the parts of the leaves to which the eggs were attached were a foot or more above the surface of the water which contained the layer of kerosene. Even under these conditions an exact count could not be obtained, because the kerosene appeared to affect different specimens differently. Some were killed very quickly, some died after an hour or more, while others did not appear to suffer particular inconvenience from the treatment. Further observation is necessary in order to be able to give conclusive statements regarding the matter.

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